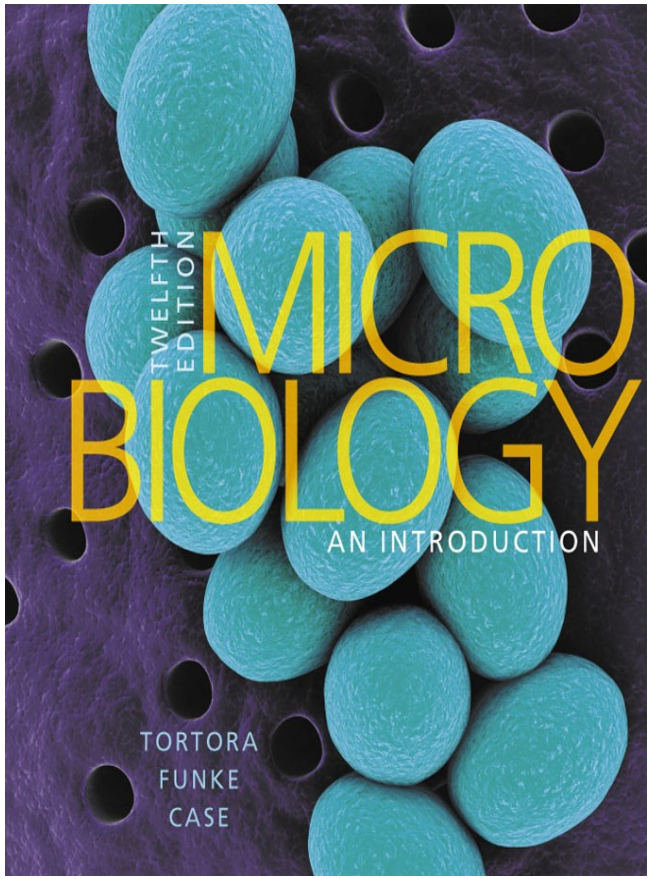
Microbiology an Introduction

Twelfth Edition

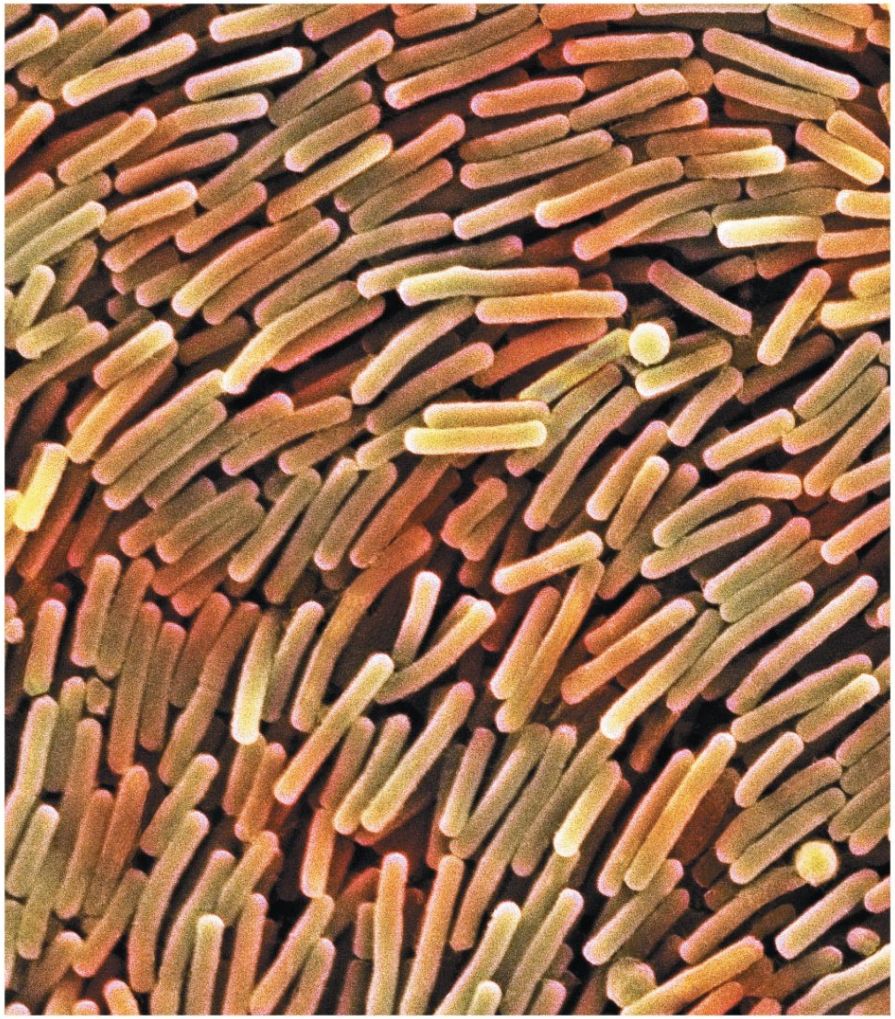


Chapter 14

Principles of Disease and Epidemiology

Pearson

Clostridium Difficile



Pathology, Infection, and Disease (1 of 2)

Learning Objective

14-1 Define **pathology, etiology, infection,** and **disease**.

Pathology, Infection, and Disease (2 of 2)

- **Pathology:** the study of disease
- **Etiology:** the cause of a disease
- **Pathogenesis:** the development of disease
- **Infection:** invasion or colonization of the body by pathogens
- **Disease:** an abnormal state in which the body is not performing normal functions

Check Your Understanding-1

Check Your Understanding

- ✓ What are the objectives of pathology? 14-1

Normal Microbiota (1 of 3)

Learning Objectives

14-2 Define **normal** and **transient microbiota**.

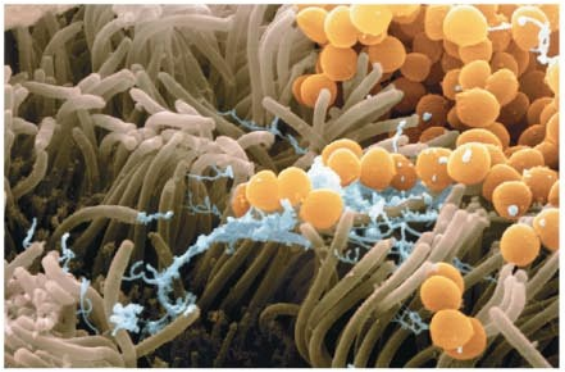
14-3 Compare commensalism, mutualism, and parasitism, and give an example of each.

14-4 Contrast normal microbiota and transient microbiota with opportunistic microorganisms.

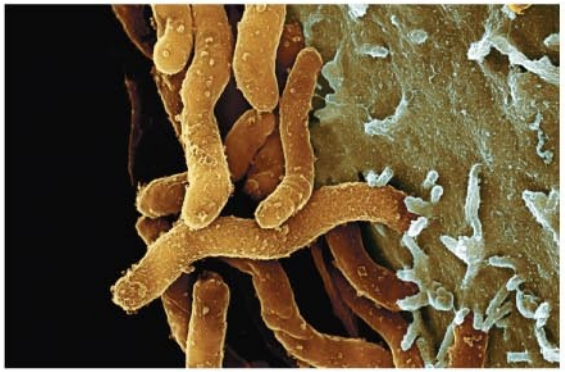
Normal Microbiota (2 of 3)

- **Transient microbiota** may be present for days, weeks, or months
- **Normal microbiota** permanently colonize the host and do not cause disease under normal conditions
- **Human Microbiome Project** analyzes relationships between microbial communities on the body and human health

Figure 14.1 Representative Normal Microbiota for Different Regions of the Body.



(a) Bacteria (orange spheres) on the surface of the nasal epithelium SEM 2 μm



(b) Bacteria (brown) on the lining of the stomach SEM 2.5 μm

(c) Bacteria (orange) in the small intestine SEM 1 μm

Normal Microbiota (3 of 3)

- Distribution and composition of normal microbiota are determined by many factors
  - Nutrients
  - Physical and chemical factors
  - Host defenses
  - Mechanical factors

Table 14.1 Representative Normal Microbiota by Body Region (1 of 4)

Table 14.1 Representative Normal Microbiota by Body Region

Region	Principal Components	Comments
Skin	**Propionibacterium, Staphylococcus, Corynebacterium, Micrococcus, Acinetobacter, Brevibacterium; Candida** (fungus), and **Malassezia** (fungus)	•Most of the microbes in direct contact with skin don't become residents because secretions from sweat and oil glands have antimicrobial properties. •Keratin is a resistant barrier, and the low pH of the skin inhibits many microbes. •The skin also has a relatively low moisture content.
Eyes (Conjunctiva)	**Staphylococcus epidermidis, S. aureus,** diphtheroids, **Propionibacterium, Corynebacterium,** streptococci, and **Micrococcus**	•The conjunctiva, a continuation of the skin or mucous membrane, contains basically the same microbiota found on the skin. •Tears and blinking also eliminate some microbes or inhibit others from colonizing.

Table 14.1 Representative Normal Microbiota by Body Region (2 of 4)

Table 14.1 Representative Normal Microbiota by Body Region

Region	Principal Components	Comments
Nose and Throat (Upper Respiratory System)	**Staphylococcus aureus, S. epidermidis**, and aerobic diphtheroids in the nose; **S. epidermidis, S. aureus,** diphtheroids, **Streptococcus pneumoniae, Haemophilus,** and **Neisseria** in the throat	•Although some normal microbiota are potential pathogens, their ability to cause disease is reduced by microbial antagonism. •Nasal secretions kill or inhibit many microbes, and mucus and ciliary action remove many microbes.
Mouth	**Streptococcus, Lactobacillus, Actinomyces, Bacteroides, Veillonella, Neisseria, Haemophilis, Fusobacterium, Treponema, Staphylococcus, Corynebacterium,** and **Candida** (fungus)	•Abundant moisture, warmth, and the constant presence of food make the mouth an ideal environment that supports very large and diverse microbial populations on the tongue, cheeks, teeth, and gums. •Biting, chewing, tongue movements, and salivary flow dislodge microbes. Saliva contains several antimicrobial substances.

Table 14.1 Representative Normal Microbiota by Body Region (3 of 4)

Table 14.1 Representative Normal Microbiota by Body Region

Region	Principal Components	Comments
Large Intestine	**Escherichia coli, Bacteroides, Fusobacterium, Lactobacillus, Enterococcus, Bifidobacterium, Enterobacter, Citrobacter, Proteus, Klebsiella,** and **Candida** (fungus)	•The large intestine contains the largest numbers of resident microbiota in the body because of its available moisture and nutrients. •Mucus and periodic shedding of the lining prevent many microbes from attaching to the lining of the gastrointestinal tract, and the mucosa produces several antimicrobiol chemicals. •Diarrhea also flushes out some of the normal microbiota.

Table 14.1 Representative Normal Microbiota by Body Region (4 of 4)

Table 14.1 Representative Normal Microbiota by Body Region

Region	Principal Components	Comments
Urinary and Reproductive Systems	**Staphylococcus, Micrococcus, Enterococcus, Lactobacillus, Bacteroides**, aerobic diphtheroids, **Pseudomonas, Klebsiella,** and **Proteus** in urethra; lactobacilli, **Streptococcus, Clostridium, Candida albicans** (fungus), and **Trichomonas vaginalis** (protozoan) in vagina	• The lower urethra in both sexes has a resident population; the vagina has its acid-tolerant population of microbes because of the nature of its secretions. • Mucus and periodic shedding of the lining prevent microbes from attaching to the lining; urine flow mechanically removes microbes, and the pH of urine and urea are antimicrobial. • Cilia and mucus expel microbes from the cervix of the uterus into the vagina, and the acidity of the vagina inhibits or kills microbes.

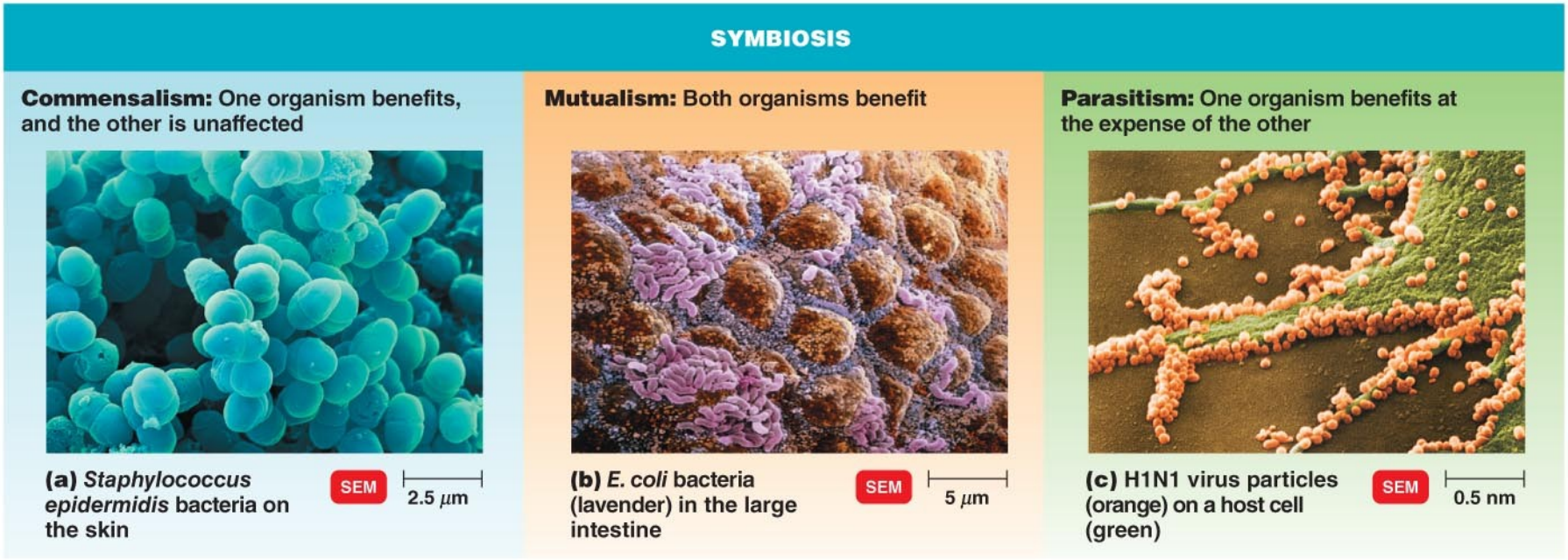
Relationships between the Normal Microbiota and the Host (1 of 2)

- **Microbial antagonism (competitive exclusion)** is a competition between microbes
- Normal microbiota protect the host by:
  - Competing for nutrients
  - Producing substances harmful to invading microbes
  - Affecting pH and available oxygen

Relationships between the Normal Microbiota and the Host (2 of 2)

- **Symbiosis** is the relationship between normal microbiota and the host
  - **Commensalism:** one organism benefits, and the other is unaffected
  - **Mutualism:** both organisms benefit
  - **Parasitism:** one organism benefits at the expense of the other
- Some normal microbiota are **opportunistic pathogens**

Figure 14.2 Symbiosis



Check Your Understanding-2

Check Your Understanding

- ✓ How do normal microbiota differ from transient microbiota?
  14-2
- ✓ Give several examples of microbial antagonism.
  14-3
- ✓ How can opportunistic pathogens cause infections?
  14-4

The Etiology of Infectious Diseases

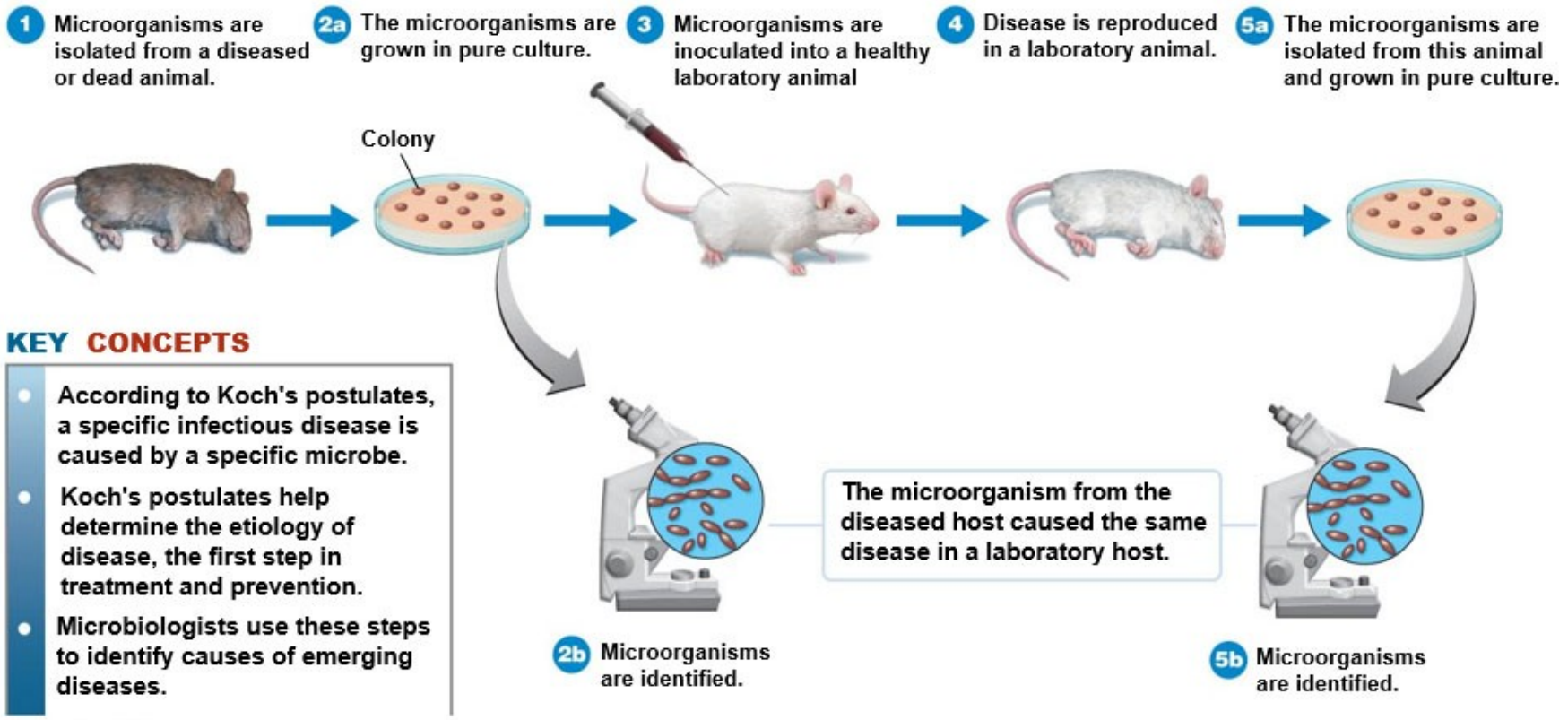
Learning Objective

14-5 List Koch's postulates.

Koch's Postulates (1 of 2)

1. The same pathogen must be present in every case of the disease.
2. The pathogen must be isolated from the diseased host and grown in pure culture.
3. The pathogen from the pure culture must cause the disease when it's inoculated into a healthy, susceptible laboratory animal.
4. The pathogen must be isolated from the inoculated animal and must be shown to be the original organism.

Figure 14.3 Koch's Postulates: Understanding Disease



Koch's Postulates (2 of 2)

- Koch's postulates are used to prove the cause of an infectious disease
- Exceptions to Koch's postulates
  - Some pathogens can cause several disease conditions
  - Some pathogens cause disease only in humans
  - Some microbes have never been cultured

Check Your Understanding-3

Check Your Understanding

- ✓ Explain some exceptions to Koch's postulates. 14-5

Classifying Infectious Diseases
(1 of 3)

Learning Objectives

14-6 Differentiate a communicable from a noncommunicable disease.

14-7 Categorize diseases according to frequency of occurrence.

14-8 Categorize diseases according to severity.

14-9 Define **herd immunity**.

Classifying Infectious Diseases
(2 of 3)

- **Symptoms:** changes in body function that are felt by a patient as a result of disease
- **Signs:** changes in a body that can be measured or observed as a result of disease
- **Syndrome:** a specific group of signs and symptoms that accompany a disease

Classifying Infectious Diseases
(3 of 3)

- **Communicable disease:** a disease that is spread from one host to another
- **Contagious diseases:** diseases that are easily and rapidly spread from one host to another
- **Noncommunicable disease:** a disease that is not spread from one host to another

Epidemiology: Overview

Animation: Epidemiology: Overview

Occurrence of a Disease (1 of 2)

- **Incidence:** number of people who develop a disease during a particular time period
- **Prevalence:** number of people who develop a disease at a specified time, regardless of when it first appeared
  - Takes into account both old and new cases

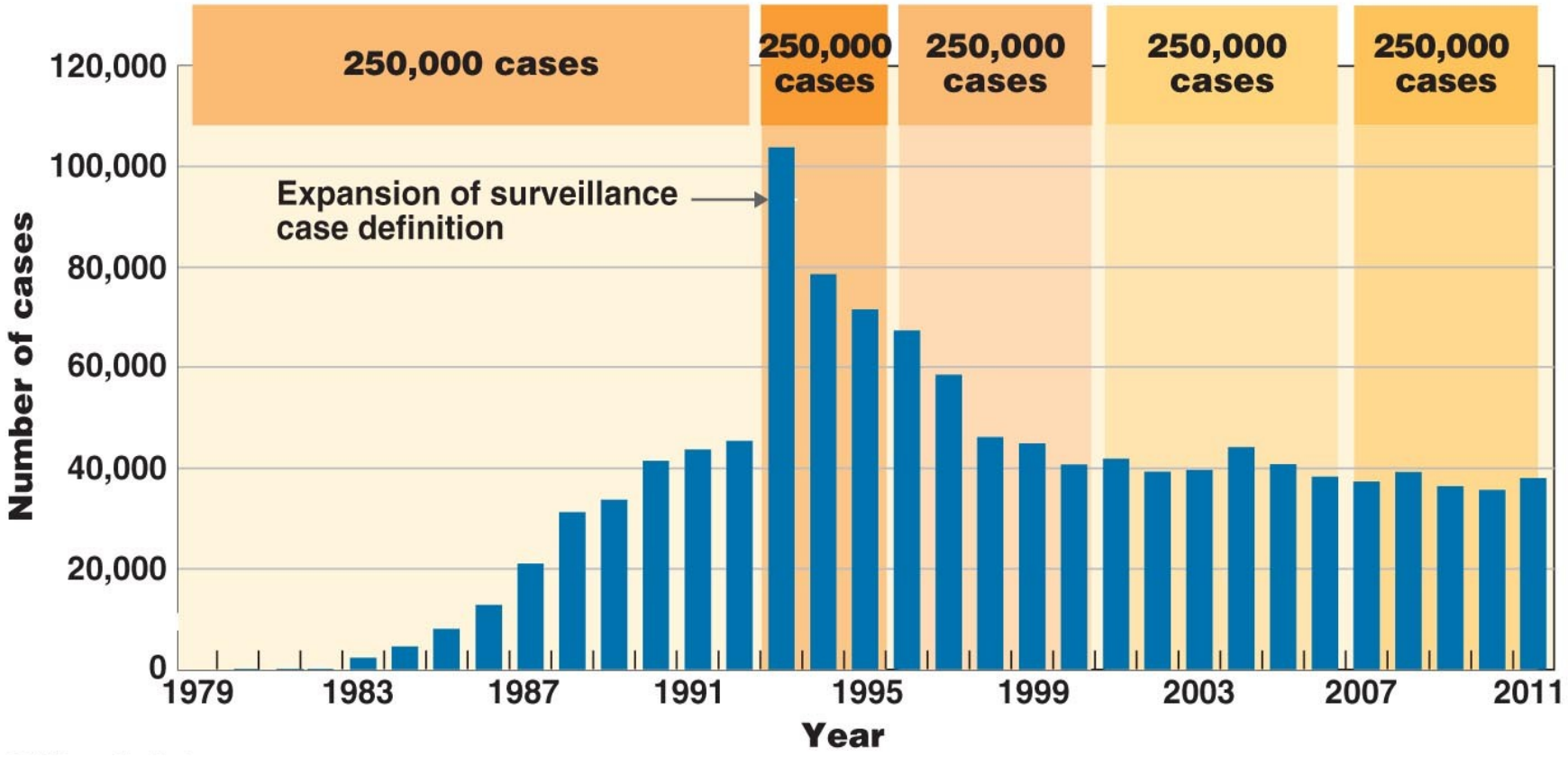
Epidemiology: Occurrence of Diseases

Animation: Epidemiology: Occurrence of Diseases

Occurrence of a Disease (2 of 2)

- **Sporadic disease:** disease that occurs only occasionally
- **Endemic disease:** disease constantly present in a population
- **Epidemic disease:** disease acquired by many people in a given area in a short time
- **Pandemic disease:** worldwide epidemic

Figure 14.4 Reported AIDS Cases in the United States



Severity or Duration of a Disease

- **Acute disease:** symptoms develop rapidly but the disease lasts only a short time
- **Chronic disease:** symptoms develop slowly
- **Subacute disease:** intermediate between acute
and chronic
- **Latent disease:** causative agent is inactive for a time but then activates and produces symptoms
- **Herd immunity:** immunity in most of a population

Extent of Host Involvement (1 of 3)

- **Local infection:** pathogens are limited to a small area of the body
- **Systemic (generalized) infection:** an infection throughout the body
- **Focal infection:** systemic infection that began as a local infection

Extent of Host Involvement (2 of 3)

- **Sepsis:** toxic inflammatory condition arising from the spread of microbes, especially bacteria or their toxins, from a focus of infection
- **Bacteremia:** bacteria in the blood
- **Septicemia:** also known as blood poisoning; growth of bacteria in the blood

Extent of Host Involvement (3 of 3)

- **Toxemia:** toxins in the blood
- **Viremia:** viruses in the blood
- **Primary infection:** acute infection that causes the initial illness
- **Secondary infection:** opportunistic infection after a primary (predisposing) infection
- **Subclinical disease:** no noticeable signs or symptoms (inapparent infection)

Check Your Understanding-4

Check Your Understanding

- ✓ Does **Clostridium perfringens** cause a communicable disease?
  14-6
- ✓ Distinguish the incidence from the prevalence of a disease.
  14-7
- ✓ List two examples of acute and chronic diseases.
  14-8
- ✓ How does herd immunity develop?
  14-9

Patterns of Disease

Learning Objectives

14-10 Identify four predisposing factors for disease.

14-11 Put the following in proper sequence, according to the pattern of disease: period of decline, period of convalescence, period of illness, prodromal period, incubation period.

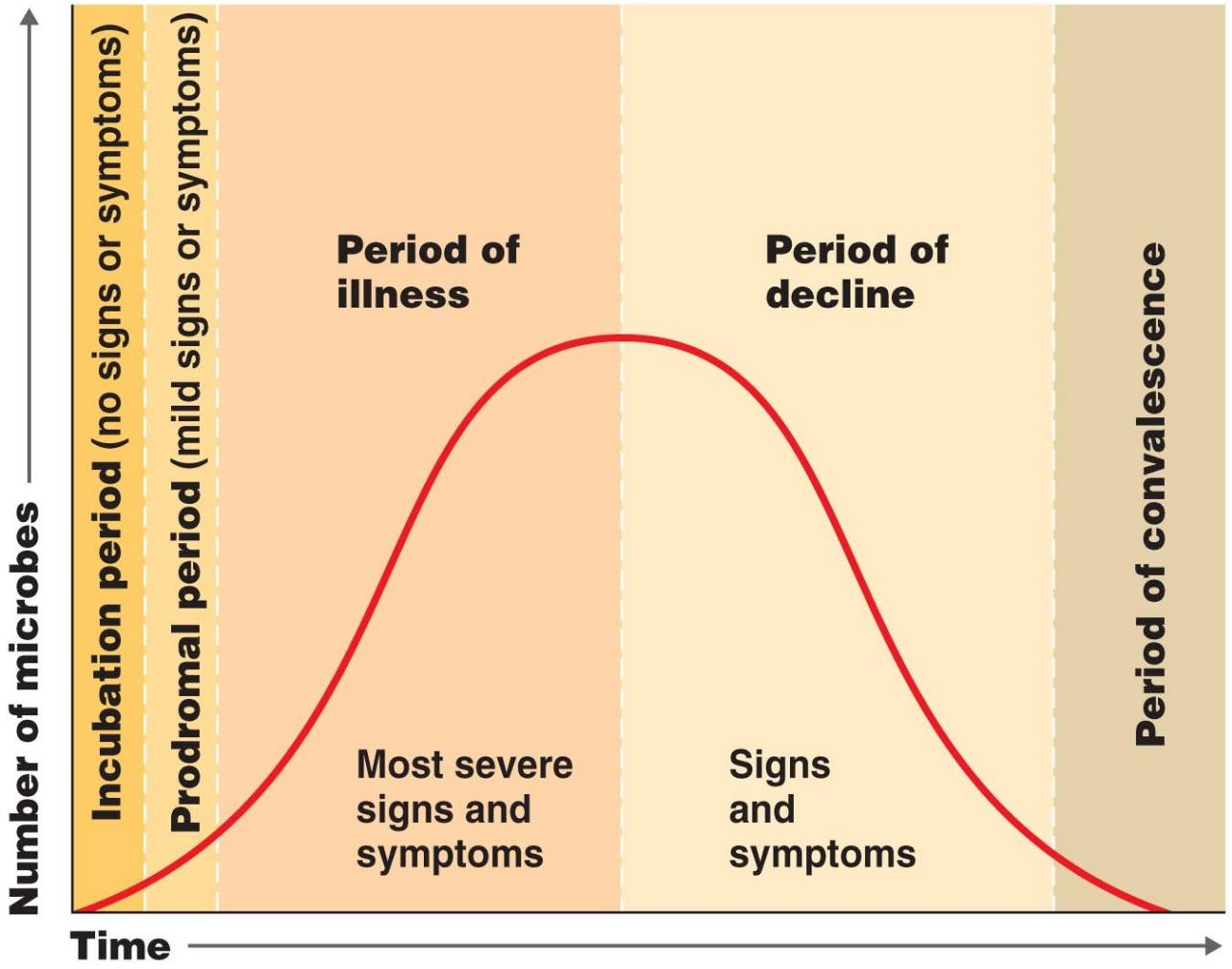
Predisposing Factors

- Make the body more susceptible to disease
  - Gender
  - Inherited traits, such as the sickle cell gene
  - Climate and weather
  - Fatigue
  - Age
  - Lifestyle
  - Nutrition
  - Chemotherapy

Development of Disease

- **Incubation period:** interval between initial infection and first signs and symptoms
- **Prodromal period:** short period after incubation; early, mild symptoms
- **Period of illness:** disease is most severe
- **Period of decline:** signs and symptoms subside
- **Period of convalescence:** body returns to its prediseased state

Figure 14.5 The Stages of a Disease



Check Your Understanding-5

Check Your Understanding

- ✓ What is a predisposing factor?
  14-10
- ✓ The incubation period for a cold is 3 days, and the period of disease is usually 5 days. If the person next to you has a cold, when will you know whether you contracted it?
  14-11

The Spread of Infection

Learning Objectives

14-12 Define **reservoir of infection**.

14-13 Contrast human, animal, and nonliving reservoirs, and give one example of each.

14-14 Explain three methods of disease transmission.

Reservoirs of Infection

- Continual sources of infection
  - **Human reservoirs**
    - **Carriers** may have inapparent infections or latent diseases
  - **Animal reservoirs**
    - **Zoonoses** are diseases transmitted from animals to humans
  - **Nonliving reservoirs**
    - Soil and water

Contact Transmission

- **Direct contact transmission:** requires close association between the infected and a susceptible host
- **Indirect contact transmission:** spreads to a host by a nonliving object called a **fomite**
- **Droplet transmission:** transmission via airborne droplets less than 1 meter

Figure 14.6 Contact Transmission

(a) Direct contact transmission

(b) Preventing direct contact transmission through the use of gloves, masks, and face shields

(c) Indirect contact transmission

(d) Droplet transmission

Vehicle Transmission

- Transmission by an inanimate reservoir
  - Waterborne
  - Foodborne
  - Airborne

Figure 14.7 Vehicle Transmission

(a) Water

(b) Food

(c) Air

Vectors

- Arthropods, especially fleas, ticks, and mosquitoes
- Transmit disease by two general methods
  - **Mechanical transmission:** arthropod carries pathogen on its feet
  - **Biological transmission:** pathogen reproduces in the vector; transmitted via bites or feces

Figure 14.8 Mechanical Transmission

Epidemiology: Transmission of Disease

Animation: Epidemiology: Transmission of Disease

Check Your Understanding-6

Check Your Understanding

- ✓ Why are carriers important reservoirs of infection? 14-12
- ✓ How are zoonoses transmitted to humans? 14-13
- ✓ Give an example of contact transmission, vehicle transmission, mechanical transmission, and biological transmission. 14-14

Healthcare-Associated Infections (HAIs) (1 of 3)

Learning Objectives

14-15 Define healthcare-associated **infections**, and explain their importance.

14-16 Define **compromised host**.

14-17 List several methods of disease transmission in hospitals.

14-18 Explain how healthcare-associated infections can be prevented.

Healthcare-Associated Infections (HAIs) (2 of 3)

- Acquired while receiving treatment in a health care facility
  - Also known as **nosocomial infections**
- Affect 1 in 25 hospital patients
  - 2 million per year infected; 20,000 deaths

Nosocomial Infections: Overview

Animation: Nosocomial Infections: Overview

Healthcare-Associated Infections (HAIs) (3 of 3)

- HAIs result from:
  - Microorganisms in the hospital environment
  - Weakened status of the host
  - Chain of transmission in a hospital
- **Compromised host:** an individual whose resistance to infection is impaired by disease, therapy, or burns

Figure 14.9 Healthcare-Associated Infections

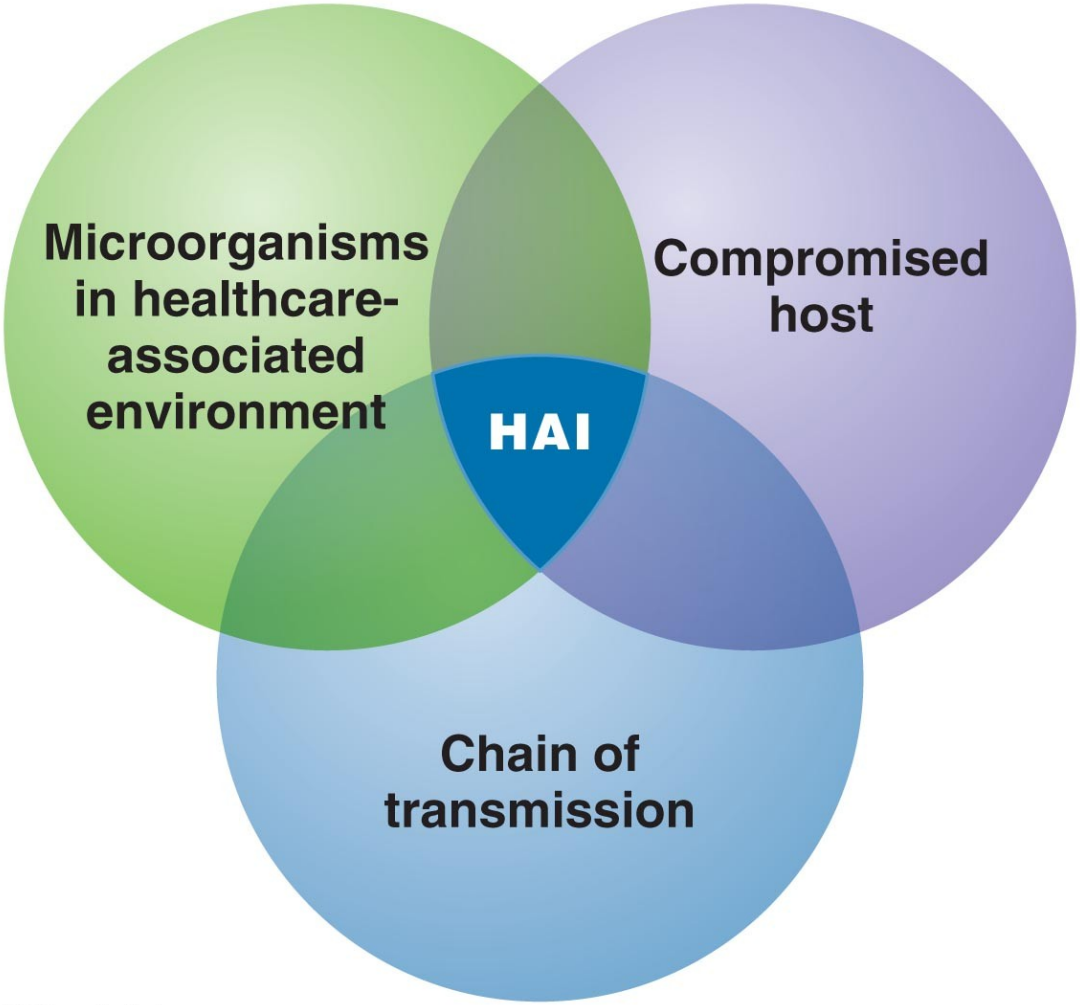


Table 14.4 Microorganisms Involved in Healthcare-Associated Infections

Table 14.4 Microorganisms Involved in Healthcare-Associated Infections

Microorganism	Most Common Infection Type	Percentage of Total Infections	Percentage Resistant to Antibiotics
Coagulase-negative staphylococci	Bloodstream	11%	Not reported
Staphylococcus aureus	Surgical wound	16%	55%
Clostridium difficile	Diarrhea after abdominal surgery	15%	Not reported
Enterococcus spp.	Bloodstream	14%	83%
Candida spp. (fungus)	Urinary tract infections	9%	Not reported
Escherichia coli	Urinary tract infections (most common cause)	12%	20%
Pseudomonas aeruginosa	Urinary tract and pneumonia	8%	10%
Klebsiella pneumoniae	All sites	8%	29%
Enterobacter spp.	All sites	5%	38%
Acinetobacter baumannii	All sites	2%	68%

Source: CDC, Healthcare-Associated Infections.

Control of Healthcare-Associated Infections

- Reduce number of pathogens
  - Handwashing
  - Disinfecting tubs used to bathe patients
  - Cleaning instruments scrupulously
  - Using disposable bandages and intubation
- Infection control committees

Nosocomial Infections: Prevention

Animation: Nosocomial Infections: Prevention

Check Your Understanding-7

Check Your Understanding

- ✓ What interacting factors result in nosocomial infections?
  14-15
- ✓ What is a compromised host?
  14-16
- ✓ How are nosocomial infections primarily transmitted, and how can they be prevented
  14-17, 14-18

Emerging Infectious Diseases (1 of 4)

Learning Objective

14-19 List several probable reasons for emerging infectious diseases, and name one example for each reason.

Emerging Infectious Diseases (2 of 4)

- Diseases that are new, increasing in incidence, or showing a potential to increase in the near future
- Most are zoonotic, of viral origin, and likely to be vector-borne

Emerging Infectious Diseases (3 of 4)

- Contributing factors
  - Genetic recombination
    - **Escherichia coli** O157 and avian influenza (H5N1)
  - Evolution of new strains
    - **Vibrio cholerae** O139
  - Widespread use of antibiotics and pesticides
    - Antibiotic-resistant strains
  - Changes in weather patterns
    - **Hantavirus**

Emerging Infectious Diseases (4 of 4)

- Contributing factors
  - Modern transportation
    - Chikungunya and West Nile virus
  - Ecological disaster, war, and expanding human settlement
    - Coccidioidomycosis
  - Animal control measures
    - Lyme disease
  - Public health failure
    - Diphtheria

Check Your Understanding-8

Check Your Understanding

- ✓ Give several examples of emerging infectious diseases.
  14-19

Epidemiology (1 of 4)

Learning Objectives

14-20 Define **epidemiology**, and describe three types of epidemiologic investigations.

14-21 Identify the function of the CDC.

14-22 Define the following terms: **morbidity, mortality,** and **notifiable infectious diseases**.

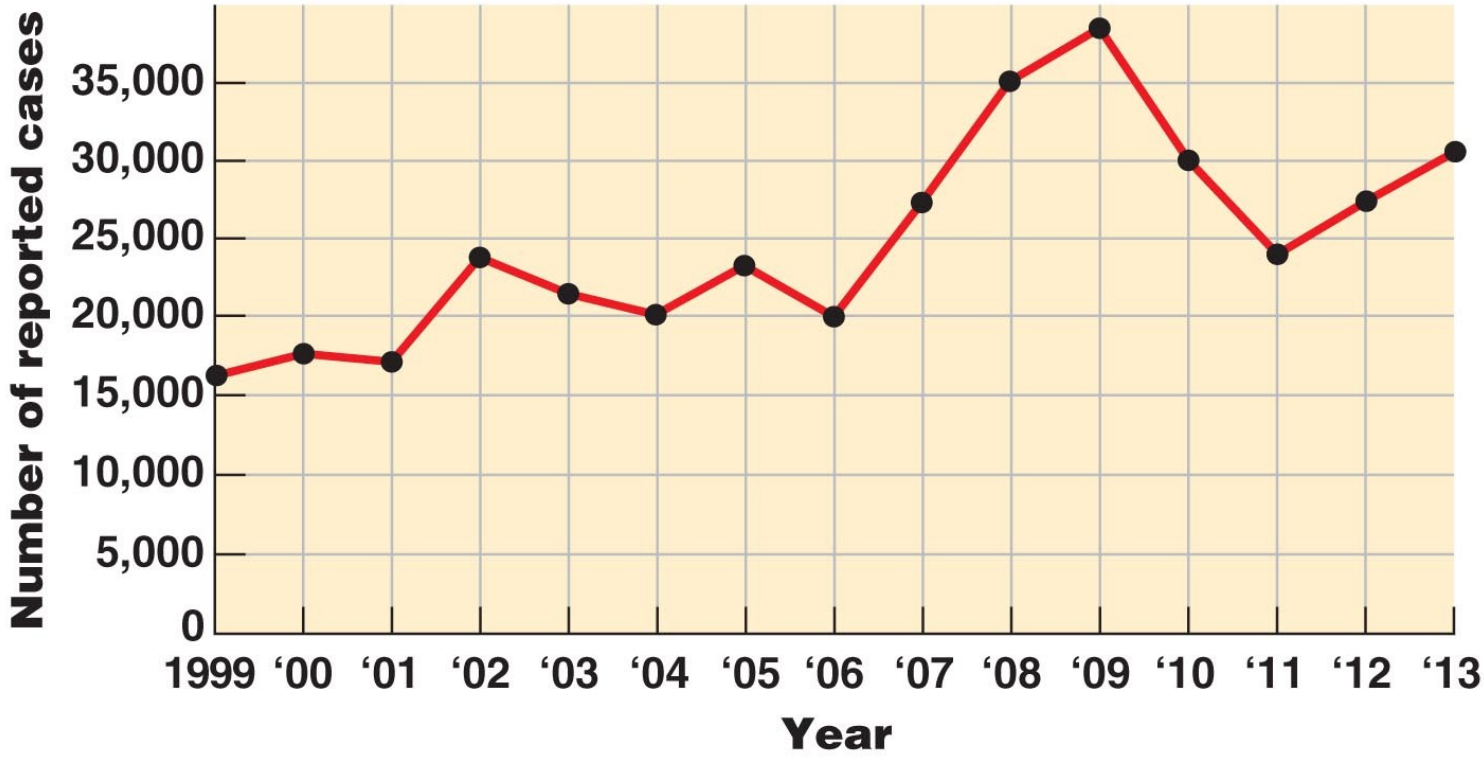
Epidemiology (2 of 4)

- The study of where and when diseases occur and how they are transmitted in populations
- Epidemiologists:
  - Determine etiology of a disease
  - Identify other important factors concerning the spread of disease
  - Develop methods for controlling a disease
  - Assemble data and graphs to outline incidence of disease

Epidemiology (3 of 4)

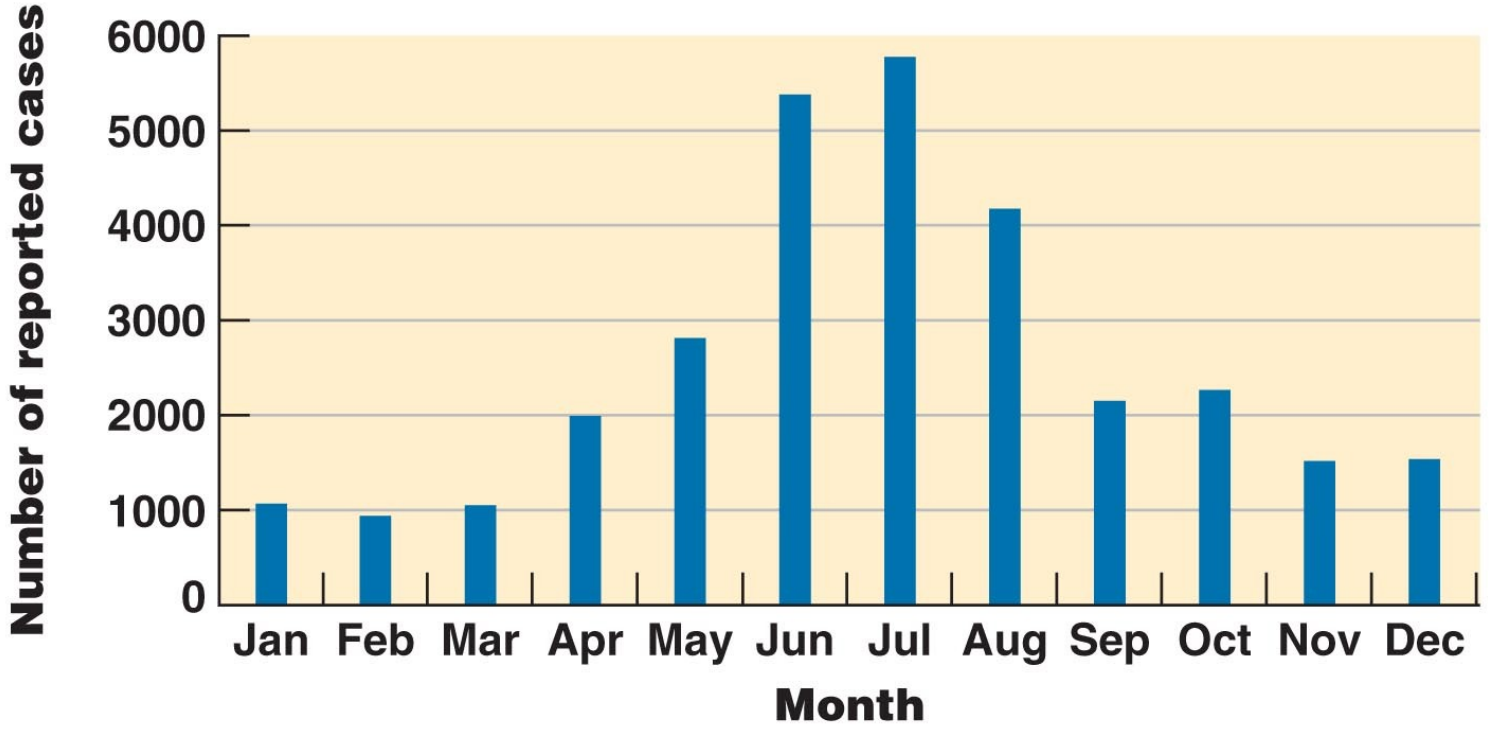
John Snow	1848–1849	Mapped the occurrence of cholera in London
Ignaz Semmelweis	1846–1848	Showed that handwashing decreased the incidence of peurperal sepsis
Florence Nightingale	1858	Showed that improved sanitation decreased the incidence of epidemic typhus

Figure 14.10a Epidemiological Graphs



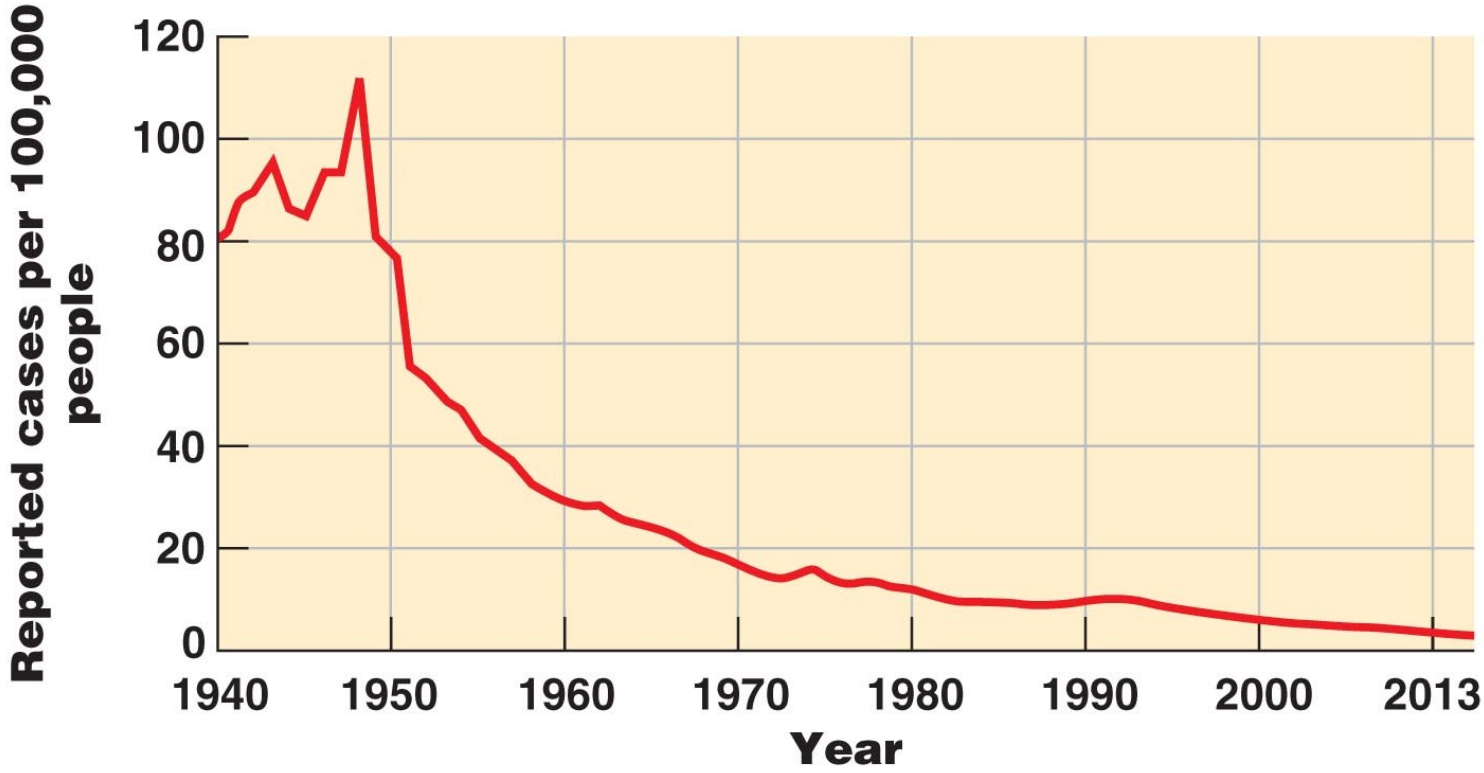
(a) Lyme disease cases, 1999–2013

Figure 14.10b Epidemiological Graphs



(b) Lyme disease by month, 2012

Figure 14.10c Epidemiological Graphs



(c) Reported tuberculosis cases, 1940–2013

Pearson

Epidemiology (4 of 4)

- **Descriptive epidemiology:** collection and analysis of data
  - Snow
- **Analytical epidemiology:** analyzes a particular disease to determine its probable cause
  - Nightingale
- **Experimental epidemiology:** involves a hypothesis and controlled experiments
  - Semmelweis

The Centers for Disease Control and Prevention (CDC) (1 of 2)

- Collects and analyzes epidemiological information in the United States
- Publishes **Morbidity and Mortality Weekly Report** (**MMWR**)
  - **Morbidity**: incidence of a specific notifiable disease
  - **Mortality**: deaths from notifiable diseases

The Centers for Disease Control and Prevention (CDC) (2 of 2)

- **Notifiable infectious diseases:** diseases in which physicians are required to report occurrence
- **Morbidity rate:** number of people affected in relation to the total population in a given time period
- **Mortality rate:** number of deaths from a disease in relation to the population in a given time

Figure 14.11 Nationally notifiable diseases, 2013 (1 of 2)

Nationally notifiable diseases, 2013

Anthrax

Arboviral diseases: neuroinvasive, non-neuroinvasive

Babesiosisa

Botulism

Brucellosis

Chancroid

Chlamydia trachomatis infection

Cholera

Coccidioidomycosis

Cryptosporidiosis

Cyclosporiasis

Dengue virus infections

Diphtheria

Ehrlichiosis and anaplasmosis

Giardiasis

Gonorrhea

Haemophilus influenzae, invasive disease

Hansen's disease (leprosy)

Hantavirus pulmonary syndrome

Hemolytic uremic syndrome, post-diarrheal

Hepatitis A, B, and C

HIV Infection

Influenza-associated pediatric mortality

Invasive pneumococcal disease

Legionellosis

Listeriosis

Lyme disease

Malaria

Measles

Meningococcal disease

Mumps

Novel influenza A virus infections

Pertussis

Plague

Poliomyelitis

Psittacosis

Q fever

Rabies, animal or human

Rubella

Salmonellosis

Severe acute respiratory syndrome associated coronavirus disease

Shiga toxin–producing **E. coli**

Shigellosis

Figure 14.11 Nationally notifiable diseases, 2013 (2 of 2)

Nationally notifiable diseases, 2013

Smallpox

Spotted fever rickettsiosis

Syphilis

Tetanus

Toxic shock syndrome (streptococcal and nonstreptococcal)

Trichinellosis

Tuberculosis

Tularemia

Typhoid fever

Vancomycin-intermediate **Staphylococcus aureus** (VISA)

Vancomycin-resistant **Staphylococcus aureus** (VRSA)

Varicella

Vibriosis

Viral hemorrhagic fever

Yellow fever

Check Your Understanding-9

Check Your Understanding

- ✓ After learning that 40 hospital employees developed nausea and vomiting, the hospital infection control officer determined that 39 ill people ate green beans in the hospital cafeteria, compared to 34 healthy people who ate in the cafeteria the same day but did not eat green beans in the hospital cafeteria. What type of epidemiology is this?
  14-20

Check Your Understanding-10

Check Your Understanding

- ✓ What is the CDC's function?
  14-21
- ✓ In 2012, the morbidity of West Nile encephalitis was 5674, and the mortality was 286. The morbidity of listeriosis was 121, and the mortality was 13. Which disease is more likely to be fatal?
  14-22

Clinical Focus: Healthcare-Associated Infections

- Blood cultures grown on mannitol-salt agar; coagulase-positive; gram-positive cocci
  - Methicillin-resistant **Staphylococcus aureus**
    - Strain USA100: 92% of health care strains
    - Strain USA300: 89% of community-acquired strains

Clinical Focus 14.1a

Clinical Focus 14.2

Table A

Procedure	MRSA-Infected Patients	Total Number of Patients Receiving Procedure
Hemodialysis	813	1807
Intravenous (IV) catheter	1057	16,516
Surgery	945	5659
Urinary bladder catheter	1750	7919
Ventilator (invasive airway)	722	7367
Antibiotic Use during the 6 Months Prior to Infection		
Vancomycin	21	41
Fluoroquinolone	49	113
Ceftriaxone	14	41